Agilent 8163A/4A/6A Lightwave Series Mainframes

Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Power Sensor Module

User's Guide

Agilent Technologies
Innovating the HP Way

Second Edition

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Safety Considerations

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies Company assumes no liability for the customer's failure to comply with these requirements.

Before operation, review the instrument and manual, including the red safety page, for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Safety Symbols

The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.

Initial Inspection

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically.

The Performance Tests give procedures for checking the operation of the instrument. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Agilent Technologies Sales/Service Office.

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

Line Power Requirements

The Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Power Sensor Module operate when installed in the Agilent 8163A Lightwave Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System.

Operating Environment

The safety information in the Agilent 8163A Lightwave Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System User's Guide summarizes the operating ranges for the Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Power Sensor Module. In order for these modules to meet specifications, the operating environment must be within the limits specified for the Agilent 8163A Lightwave Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System.

Storage and Shipment

This module can be stored or shipped at temperatures between –40°C and +70°C. Protect the module from temperature extremes that may cause condensation within it.

Contents

Accessories

The Agilent 81632A/3A/4A Power Sensor Module and the Agilent 81635A Dual Power Sensor Module are available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

Modules and Options

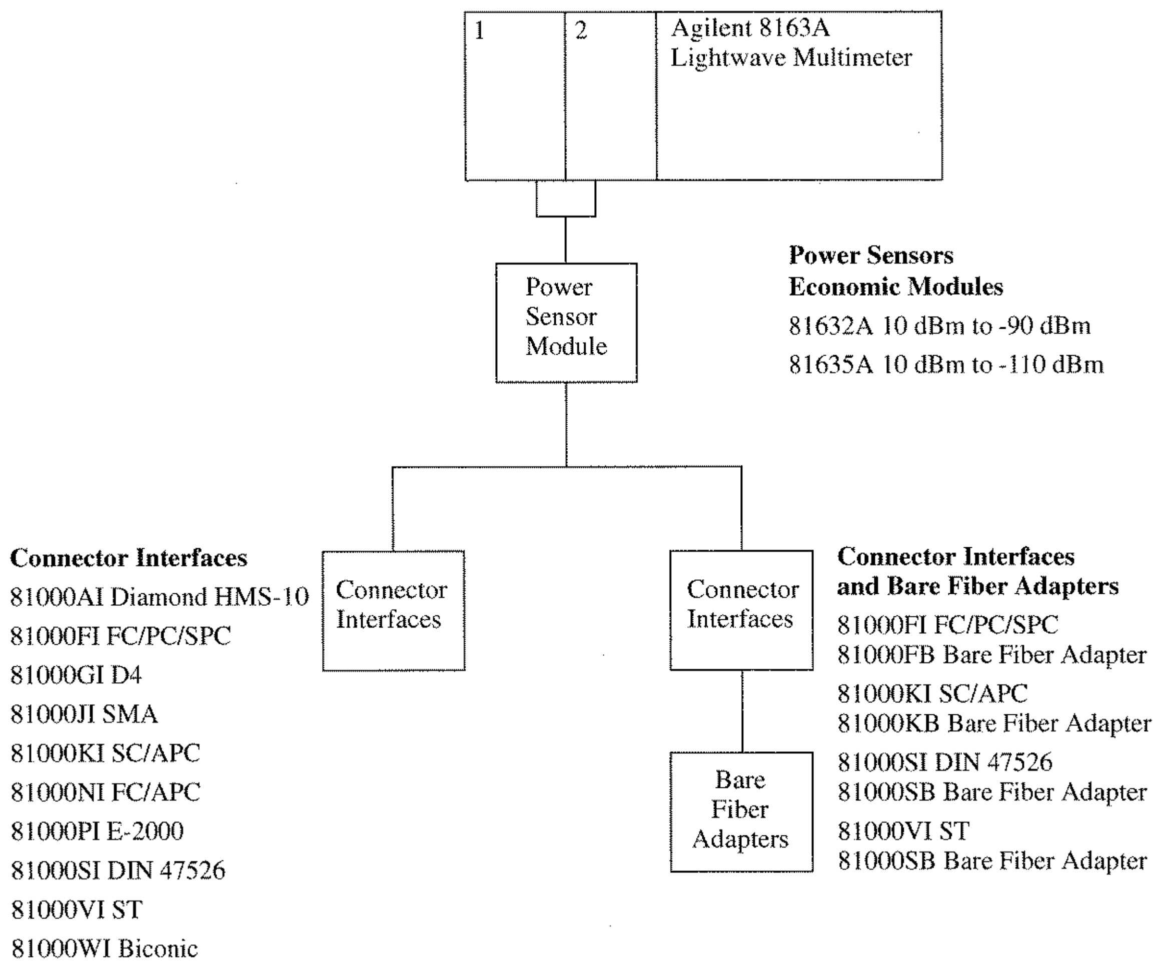

Figure 1 Recommended Connector Interfaces and Bare Fiber Adapters

Table 1 Connector Interfaces

Product Number	Connector InterfaceType
81000AI	Diamond HMS-10
81000FI	FC/PC/SPC
81000GI	D4
81000JI	SMA
81000KI	SC/APC

Table 1 Connector Interfaces

Product Number	Connector InterfaceType
81000NI	FC/APC
81000PI	E-2000
81000SI	DIN 47526
81000VI	ST
81000WI	Biconic

Table 2 Connector Interface and Bare Fiber Adapter Combinations

Product Number	Bare Fiber Adapter	Product Number	Connector Interface
81000FB	Bare Fiber Adapter	81000FI	FC/PC/SPC
81000KB	Bare Fiber Adapter	81000KI	SC/APC
81000SB	Bare Fiber Adapter	81000SI	DIN 47526
81000SB	Bare Fiber Adapter	81000VI	ST

Specifications

Agilent 81632A/3A/4A Power Sensor Modules and the Agilent 81635A Dual Power Sensor Module are produced to the ISO 9001 international quality system standard as part of Agilent's commitment to continually increasing customer satisfaction through improved quality control.

Specifications describe the modules' and heads' warranted performance. Supplementary performance characteristics describe the modules' and heads' non-warranted typical performance.

Because of the modular nature of the instrument, these performance specifications apply to these modules and heads rather than the mainframe unit.

Definition of Terms

This section defines terms that are used both in this chapter and *"Performance Tests" on page 21*.

Generally, all specifications apply for the given environmental conditions and after warmup time.

Measurement principles are indicated. Alternative measurement principles of equal value are also acceptable.

Averaging Time

Time defining the period during which the power meter takes readings for averaging. At the end of the averaging time the average of the readings is available (display- or memory-update). Symbol T_{avg}.

Linearity

The linearity error is defined as the relative difference between the displayed power ratio, D_x/D_0, and the actual (true) power ratio P_x/P_0 caused by changing the displayed power level from the reference level, D_0, to an arbitrary displayed level, D_x. Symbol N.

if expressed in %

$$N = \left(\frac{D_x/D_0}{P_x/P_0} - 1\right)100$$

if expressed in dB

$$N_{dB} = 10\log\left(\frac{D_x/D_0}{P_x/P_0}\right)$$

Conditions: reference level 10 µW, displayed power levels within the specified range, zero less than specified time prior to measurement.

Note 1: ideally $E = 0$ %, respectively 0 dB.

Note 2: the power-dependent nonlinearity, $N(P_x)$, can alternatively be expressed by the following formula:

$$N(P_x) = \frac{r(P_x) - r(P_0)}{r(P_0)}$$

where $r(P)$ is the power-dependent responsivity (for a power meter, the responsivity is defined as the ratio of displayed power to actual input power).

Linewidth

FWHM spectral bandwidth. The 3 dB width of the optical spectrum, expressed in Hertz. Symbol: Δf.

Noise

The peak-to-peak change of displayed power level with zero input power level (dark).

Conditions: Zero prior to measurement, averaging time and observation time as specified, lowest power range selected and wavelength range as specified.

Measurement: the measurement result is obtained by:

$Noise = P_{max} - P_{min}$ expressed as peak-to-peak within the given time span. Any offset is automatically excluded this way.

Power range

The power range is defined from the highest specified input power level to the smallest input power level that causes a noticable change of displayed power level.

Conditions: wavelength, averaging time as specified.

Reference conditions

The specified conditions during the spectral responsivity calibration, or conditions which are extrapolated from the conditions during calibration.

Conditions: power level, beam diameter or fiber type, numerical aperture, wavelength, spectral width, ambient temperature as specified, at the day of calibration. →Noise and drift observed over a specified observation time, with a temperature change of not more than $\pm\Delta T$.

Relative uncertainty (spectral ripple) due to interference

Uncertainty of power reading when using a coherent source, due to a periodic change of the power meter's responsivity caused by optical interference[1] between reflective interfaces within the power meter's optical assembly.

Conditions: constant wavelength, constant power level, angled connector as specified, linewidth of source <100 MHz, temperature as specified.

Relative uncertainty due to polarization

Also termed polarization-dependent responsivity (PDR), the relative uncertainty due to polarization is the uncertainty of the displayed power level on the input polarization state, expressed as the difference between the highest and the lowest displayed power. Uncertainty figures are based upon a 95% confidence level.

Conditions: laser source with variable polarization state, generation of all possible polarization states (covering the entire Poincaré sphere), constant wavelength, constant power level, angled connector as specified, temperature as specified.

Return loss:

The ratio of the incident power to the reflected power expressed in dB.
Symbol: *RL*.

$$RL = 10\log\left(\frac{P_{in}}{P_{back}}\right)$$

Conditions: the return loss excludes any reflections from the fiber end used as radiation source.

Spectral width of optical source

Full width at half maximum. The 3 dB width of the optical spectrum, expressed in nm. Symbol: *FWHM*.

Total uncertainty

The uncertainty for a specified set of operating conditions, including noise and drift.

Conditions: power level, beam diameter or fiber type, numerical aperture, wavelength, spectral width, ambient temperature, re-calibration period as specified. →Noise and drift observed over a specified observation time, with a temperature change of not more than ±ΔT.

Uncertainty at reference conditions

The uncertainty for the specified set of reference conditions, including all uncertainties in the calibration chain from the national laboratory to the test meter.

Wavelength Range

The range of wavelengths for which the power meter is calibrated.

Note: Selectable wavelength setting of the power meter for useful power measurements (operating wavelength range).

Literature

[1]***Fiber optic test and measurement***, Hewlett Packard Professional Books, edited by Prentice Hall, ISBN 0-13-534330-5

Power Sensor Specifications (Autorange Mode)

Table 3 Power Sensor Specifications

	Agilent 81632A	Agilent 81635A	Agilent 81633A	Agilent 81634A
Sensor Element	InGaAs	InGaAs (dual)	InGaAs	
Wavelength Range	800 - 1650 nm		800 - 1700 nm	
Power Range	+10 to -80 dBm		+10 to -90dBm	+10 to -100 dBm
Display Resolution	0.0001dB/dBm, 0.01pW to 10 pW (depending on power range)			
Applicable Fiber Type	Standard SM and MM up to 62.5 µm core size, NA ≤ 0.24		Standard SM and MM up to 100 µm core size, NA ≤ 0.3	
Uncertainty (accuracy) at Reference Conditions [1]	< ±3% (1200 nm to 1630 nm)		< ±2.5% (1000 nm to 1650 nm)	
Total Uncertainty [2]	< ±5% [8] (1200 nm to 1630 nm)		< ±4.5% (1000 nm to 1650 nm)	
Relative Uncertainty				
Due to Polarization [3]	± 0.015 dB typical		± 0.005 dB	
Spectral Ripple (due to interference) [4]	± 0.015 dB typical		± 0.005 dB	
Linearity (power) [5]	CW +10 to -60 dBm (1200 to 1630 nm)		CW +10 to -70 dBm	CW +10 to -90 dBm
- at 23°C ±5°C	< ± 0.02 dB ± 20 pW [9]		< ± 0.015 dB ± 2 pW	< ± 0.015 dB ± 0.2 pW
- at operating temp. range	< ± 0.06 dB ± 20 pW [9]		< ± 0.05 dB ± 2 pW	< ± 0.05 dB ± 0.5 pW
Return Loss [7]	>40 dB		>55 dB	
Noise (peak to peak) [5, 6]	< 20 pW		< 2 pW	< 0.2 pW
Averaging Time (minimal)	100 µs		100 µs	
Dimensions (H x W x D)	75 mm × 32 mm × 335 mm (2.8" × 1.3" × 13.2")			
Weight	0.5 kg			
Recalibration Period	2 years			
Operating Temperature	+10°C to +40°C		0°C to +45°C	
Humidity	Non-condensing			
Warm-up time	20 minutes			

Table 3 Power Sensor Specifications

	Agilent 81632A	Agilent 81635A	Agilent 81633A	Agilent 81634A

1 Reference Conditions

- Power level 10 µW (–20 dBm), continuous wave (CW)
- Fiber 50 µm graded-index, NA=0.2
- Ambient temperature 23°C ± 5°C
- On day of calibration (add ± 0.3% for ageing over one year; add ± 0.6% over two years)
- Spectral width of source < 10 nm (FWHM)
- Wavelength setting at Power Meter must correspond to source wavelength ± 0.4 nm

2 Total uncertainty includes polarization, interference, linearity conditions:

- Fiber ≤ 50 µm, NA ≤ 0.2
- Only Agilent 81632A and Agilent 81635A: For fiber 62.5 µm graded-index (NA=0.24): add ± 2 %
- Within one year of calibration, add 0.3% for second year
- Add ±1% for Biconic connector

3 All states of polarization at constant wavelength (1550 nm ± 30 nm) and constant power, straight connector, T=23°C±5 °C

For angled connector (8°C) add 0.01 dB typ.

4 Conditions:

Wavelength 1550 nm ± 30 nm, fixed state of polarization, constant power, Temperature 23°C ± 5°C

Linewidth of source ≥ 100 MHz, angled connector 8°.

5 At constant temperature ΔT = ± 1°C

6 Averaging time 1 s, T = 23°C ± 5 °C, observation time 300 s. Wavelength range 1200 - 1630 nm.

7 Conditions

- Wavelengths 1310 nm ± 30 nm and 1550 nm ± 30 nm
- Standard single-mode fiber, angled connector min 8°
- T= 23°C ± 5 °C

8 For wavelengths >1600 nm add ±0.06 %/nm

9 For input power >2 mW add ±0.02 dB

Performance Tests

The procedures in this section test the performance of the instrument. The complete specifications to which the Agilent 81632A/3A/4A Power Sensor Modules and the Agilent 81635A Dual Power Sensor Module are tested are given in *"Specifications" on page 13*. All tests can be performed without access to the interior of the instrument. The performance tests refer specifically to tests using the Diamond HMS-10/Agilent connector.

Equipment Required

Equipment required for the performance test is listed in the table below. Any equipment that satisfies the critical specifications of the equipment given in the table may be substituted for the recommended models.

Table 4 Required Equipment

Instrument/Accessory	Recommended Model	8163xA 2A	5A	3A	4A	Required Characteristics	Alternative Models
Multimeter Mainframe	Agilent 8163A (2 each)	x	x	x	x		Agilent 8164A
CW Laser Module	Agilent 81656A	x	x	x	x		Agilent 81657A
CW Laser Module	HP 81554SM	x	x	x	x		Agilent 81657A
Power Meter Standard	HP 81533B Optical Head Interface Module with HP 81521B #C01 Working Standard Optical Head	x	x	x	x		
Power Sensor Module	HP 81532A	x	x	x	x		Agilent 81634A
Optical Attenuator	Agilent 8156A #221	x	x	x	x		
Optical Attenuator	Agilent 8156A #101	x	x	x	x		HP 8157A or HP 8158B #002
Backreflector Kit	Agilent 8156A #203	x	x	x	x		
Return Loss Module	HP 81534A	x	x	x	x		
Tunable Laser Source	Agilent 8164A and Agilent 81680A #022	-	-	o	o		HP 8168E/F #022
Polarization Controller	HP 11698A	-	-	o	o		
Wavelength Independed Coupler (3 dB)	Special Tool	-	-	o	o		
Best IF Adapter	Special Tool	-	-	o	o		
Singlemode Fiber	Agilent 81101AC (2 each)	x	x	x	x		
	Agilent 81102SC (1 each)	x	x	x	x		
	Agilent 81109AC (1 each)	x	x	x	x		
	Agilent 81113PC (3 each)	x	x	x	x		
	Agilent 81113SC (1 each)	x	x	x	x		
Connector Adapters	Agilent 81000AA (1 each)	x	x	x	x		
Connector Interfaces	Agilent 81000AI (5 each)	x	x	x	x		
	Agilent 81000FI (3 each)	x	x	x	x		
	Agilent 81000SI (5 each)	x	x	x	x		
Plastic Cap	PN 5040-9351	x	x	x	x		
DIN Feedthrough	PN 1005-0255	x	x	x	x		

Legend:

- \- not applicable
- x necessary
- o optional

Test Record

Results of the performance test may be tabulated on the Test Record provided at the end of the test procedures. It is recommended that you fill out the Test Record and refer to it while doing the test. Since the test limits and setup information are printed on the Test Record for easy reference, the record can also be used as an abbreviated test procedure (if you are already familiar with the test procedures). The Test Record can also be used as a permanent record and may be reproduced without written permission from Hewlett-Packard.

Test Failure

If the Agilent 81632A/3A/4A/5A fails any performance test, return the instrument to the nearest Agilent TechnologiesSales/Service Office for repair.

Instrument Specification

Specifications are the performance characteristics of the instrument that is certified. These specifications, listed in *"Specifications" on page 13*, are the performance standards or limits against which the Agilent 81632A/3A/4A/5A can be tested. *"Specifications" on page 13* also lists some supplemental characteristics of the Agilent 81632A/3A/4A/5A. Supplemental characteristics should be considered as additional information.

Any changes in the specifications due to manufacturing changes, design, or traceability to the National Institute of Standards and Technology (NIST), will be covered in a manual change supplement, or revised manual. Such specifications supercede any that were previously published.

Performance Test

The performance test given in this section includes the Accuracy Test, the Linearity Test, the Return Loss Test and the Noise Test. The performance test for the Agilent 81633A and Agilent 81634A also includes – as optional tests – the Relative Polarization Uncertainty and the Relative Interference Uncertainty Test. Perform each step in the order given, using the corresponding test equipment.

NOTE Make sure that all optical connections are dry and clean. DO NOT USE INDEX MATCHING OIL. For cleaning, use the cleaning instructions given in *"Cleaning Procedure" on page 55*.

Fix the optical cables that connect the laser source and Power Meter to the Agilent 8156A Attenuator. This ensures minimum cable movement during the tests.

Accuracy Test

NOTE The linearity test must only be performed at either 1310 nm or 1550 nm. The accuracy test must be performed in the -20 dBm range at 10 μW at both 1310 nm and 1550 nm.

Test Setup

1 Make sure that cable connector, detectors and adapters are clean.

2 Connect the equipment as shown in Figure 2. Instead of a HP 81554SM Laser Source you can also use a Agilent 81657A Laser Source. Ensure that the cables to and from the attenuator are fixed on the table and that both the optical head and the DUT are close together so that minimum cable movement is required when connecting the cable to the head or to the DUT.

3 Move to the Laser Source channel, move to the wavelength parameter, [λ], press *Enter*, select the lower wavelength source, and press *Enter*.

4 If you are using a Agilent 81657A Laser Source ensure to initialize the Agilent 8156A Optical Attenuator with 30 dB attenuation.

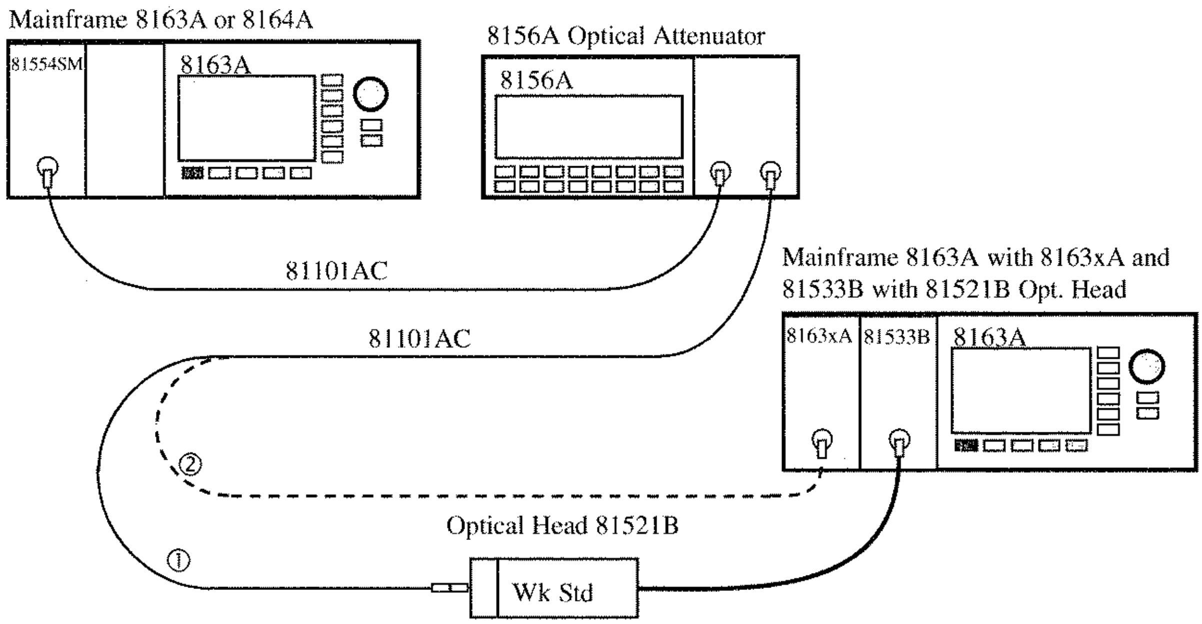

Figure 2 Accuracy Test Setup

5 Turn the instruments on, enable the laser source and allow the instruments to warm up for at least 20 minutes.

6 Perform the following sub-procedure for both Power Meters:

- **a** Move to the Power Meter channel.
- **b** Move to the wavelength parameter, [λ], press *Enter*, enter the wavelength of the laser source, and press *Enter*.
- **c** Move to the calibration parameter, [*CAL*], press *Enter*, set the calibration parameter to zero, and press *Enter*.
- **d** Move to the averaging time parameter, [*AvgTime*], press *Enter*, move to <*500 ms*>, and press *Enter*.
- **e** Move to the power parameter, [*P*], press [Pwr unit], move to <*Watt*>, and press *Enter*.

7 Make sure the optical input of the Device Under Test (DUT), 8163xA, is not receiving any light by placing a plastic cap over the input. Move to the DUT Power Meter channel, press [Menu], move to <*Zero*>, press *Enter*.

8 Ensure, that the Agilent 8156A output is disabled. Move to the reference Power Meter channel, 81532A, press [Menu], move to <*Zero*>, press *Enter*.

9 Enable the Agilent 8156A output and change the attenuation until the reference Power Meter displays 10.00 μW.

10 Connect the attenuator output cable to the DUT Power Meter. Note the power value returned from the DUT, [*P*], from the display and note the result in the test record.

11 Move to the Laser Source channel, move to the wavelength parameter, [λ], press *Enter*, select the longer wavelength source, and press *Enter*.

12 Repeat steps 4 to 10 at the second wavelength with the corresponding source.

Linearity Test

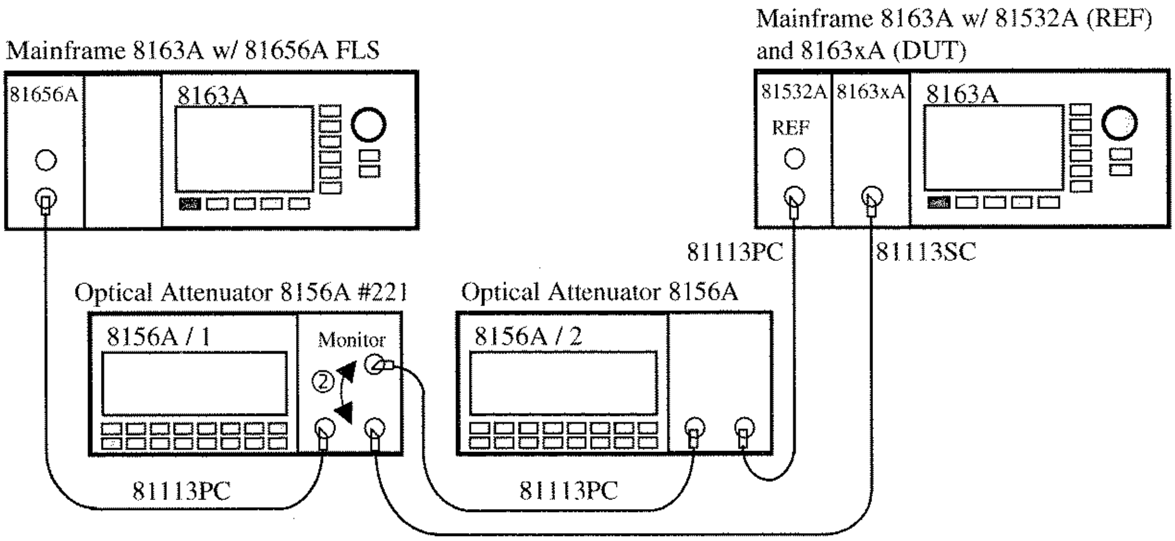

Figure 3 Measurement Setup for Power Linearity

NOTE
- Do not turn the laser off during the measurement!
- Clean all connectors carefully before you start with the measurement!

Test Setup

1 Make sure that cable connector, detectors and adapters are clean.

2 Make sure that you perform this test in a temperature-controlled environment with temperature fluctuations less than ±1°C.

3 Setup the equipment as shown in Figure 3. Disable both attenuators and enable the laser source, where the source wavelength is chosen to 1550 nm. If you are using the 81657A, move to the wavelength parameter, [λ], press *Enter*, select the longer wavelength source (1550 nm nominally), and press *Enter*.

4 Set the wavelength of both attenuators to the same wavelength as the laser source.

5 Perform the following sub-procedure for both Power Meters:

  a Move to the Power Meter channel.

  b Move to the wavelength parameter, [λ], press *Enter*, enter the wavelength of the laser source, and press *Enter*.

  c Move to the calibration parameter, [*CAL*], press *Enter*, set the calibration parameter to zero, and press *Enter*.

  d Move to the averaging time parameter, [*AvgTime*], press *Enter*, move to <*100 ms*>, and press *Enter*.

  e Move to the power parameter, [*P*], press [Pwr unit], move to <*dBm*>, and press *Enter*.

  f Press the [Menu] softkey and move to <*Number of digits*>, press *Enter*, move to <*3*>, press *Enter* and press [Close].

6 Initialize the two attenuators as follows:

  a Set the attenuation of the 8156A #221 with Monitor Output (referred to as Atty1) to 0 dB.

  b Set the attenuation of the other 8156A (referred to as Atty2) to 35 dB.

7 Wait at least 15 minutes until the laser source is stabilized.

8 Perform the following sub-procedure for the reference Power Meter, 81532A:

  a Press [Menu], move to <*Range mode*>, move to <*Manual*>, and press *Enter*.

  b Move to <*Range*>, press *Enter*, move to <*-40 dBm*>, press *Enter*, and press [Close].

9 Perform the following sub-procedure for the DUT, 8163xA:

  a Press [Menu], move to <*Range mode*>, move to <*Manual*>, and press *Enter*.

  b Move to <*Range*>, press *Enter*, move to <*10 dBm*>, and press *Enter*.

  c Zero both Power Meters. Move to <*Zero all*> and press *Enter*.

10 Enable both attenuators.

11 Adjust the attenuation of Atty2 in order to achieve -37.2 dBm on the reference Power Meter.

+10 dBm Range

12 Note both power readings as the first value in the test record, which is given at the end of the test descriptions (#1).

NOTE Always include the three digits after the decimal point when you note a power reading.

13 Increase the attenuation of Atty1 until the power reading of the DUT shows about +2.8 dBm.

14 Note the InRange-values in the test record (#2)

15 Perform the following sub-procedure for the DUT, 8163xA:

- **a** Press [Menu], move to <*Range mode*>, move to <*Manual*>, and press *Enter*.
- **b** Move to <*Range*>, press *Enter*, move to <*0 dBm*>, and press *Enter*.

16 If necessary, adjust the attenuation of Atty2 in order to be on the upper limit of the -40 dBm range (i.e. -37.2 dBm).

0 dBm Range

17 Disable Atty1.

18 Zero both Power Meters. On the 8163A with two installed power meters, press [Menu], move to <*Zero all*>, and press *Enter*.

19 Enable Atty1.

20 Switch one range up to the +10dBm range.

21 Note both power readings (#3).

22 Switch down to the previous range (0dBm) and note the values again (#4).

23 Increase Atty1 by 10 dB and note the results in the test record (#5).

24 Move to the channel of the DUT, 8163xA, press [Menu], move to <*Range*>, press *Enter*, move to <*-10 dBm*>, and press *Enter*.

25 If necessary, adjust the attenuation of Atty1 in order to be on the upper limit of the range (i.e. -x7.y dBm).

26 Decrease the attenuation of Atty2 by 10 dB in order to be on the upper limit of the -40 dBm range.

-10 dBm Range

27 Disable Atty1.

28 Zero both Power Meters. On the 8163A with two installed power meters, press [Menu], move to <*Zero all*>, and press *Enter*.

29 Enable Atty1.

30 Switch one range up to the 0 dBm range and note the power readings (#6).

31 Switch down to the previous range (-10 dBm) and note the values again (#7).

32 Increase the attenuation of Atty1 by 10 dB and note the results in the test record (#8).

33 On the DUT switch one range down to the -20 dBm range.

Change Setup

34 Disable Atty1 and switch the output with the monitor output.

35 Set the attenuation of Atty1 to 15 dB and of Atty2 to 35 dB.

36 Enable Atty1 again.

37 Adjust the attenuation of both attenuators in the following order:

- Atty1: DUT Power Meter shows a reading of -17.2 dBm and
- Atty2: the REF Power Meter shows a reading of -37.2 dBm.

-20 dBm to -50 dBm Range

38 Disable Atty1.

39 Zero both Power Meters. On the 8163A with two installed power meters, press [Menu], move to *<Zero all>*, and press *Enter*.

40 Enable Atty1.

41 Switch one range up and note both power readings.

42 Switch one range down and note the power readings again.

43 Increase the attenuation of Atty1 by 10 dB and note the results in the test record.

44 On the DUT switch one range down. Adjust the attenuation of Atty1, if necessary, so that the power displayed by the DUT is at the upper limit of the range, that is, -x7.y dBm.

45 Decrease the attenuation of Atty2 by 10 dB in order to be on the upper limit of the -40 dBm range.

Repeat step 33 to 39 until the power reading of the DUT shows -57.x dBm.

Calculation

46 Calculate the non-linearity using the formulas given in the test record.

Example: Measurement Results

Information only				Your Entries		
n	Atty1 / #221 [dB]	Atty2 / #100 [dB]	DUT Range [dBm]	REF Power [dBm]	DUT Power [dBm]	Notes
1	0	24	10	-37,291	8,957	1. Value
2	6	24	10	-42,928	3,314	InRange
3	6	18	10	-37,299	3,317	RangeDisc / lower limit
4	6	18	0	-37,298	3,318	RangeDisc / upper limit
5	16	18	0	-47,280	-6,666	InRange

Information only				Your Entries		
n	Atty1 / #221 [dB]	Atty2 / #100 [dB]	DUT Range [dBm]	REF Power [dBm]	DUT Power [dBm]	Notes
6	16	8	0	-37,301	-6,664	RangeDisc / lower limit
7	16	8	-10	-37,299	-6,662	RangeDisc / upper limit
8	26	8	-10	-47,294	-16,658	InRange
9	7,7	35,7	-10	-37,304	-17,321	RangeDisc / lower limit
10	7,7	35,7	-20	-37,302	-17,318	RangeDisc / upper limit
11	17,7	35,7	-20	-47,293	-27,309	InRange
12	17,7	25,7	-20	-37,285	-27,312	RangeDisc / lower limit
13	17,7	25,7	-30	-37,282	-27,309	RangeDisc / upper limit
14	27,7	25,7	-30	-47,280	-37,308	InRange
15	27,7	15,7	-30	-37,278	-37,306	RangeDisc / lower limit
16	27,7	15,7	-40	-37,276	-37,304	RangeDisc / upper limit
17	37,7	15,7	-40	-47,277	-47,306	InRange
18	37,7	5,7	-40	-37,274	-47,301	RangeDisc / lower limit
19	37,7	5,7	-50	-37,271	-47,298	RangeDisc / upper limit
20	47,7	5,7	-50	-47,270	-57,298	InRange

Calculations

	Conversion [dBm] → [mW]		Calculation as given		Calculation as given
n	Ref / R [mW]	DUT / D [mW]	Relation1 / A $= R_{n+1}/R_n$	Relation2 / B $= D_n/D_{n+1}$	Non-Linearity $= A_n*B_n$ $(NL_{n\pm1}+1) - 1$ ① [%]
1	1,86612E-04	7,86448E+00	2,73049E-01	3,66708E+00	-0,02
2	5,09542E-05	2,14462E+00			
3	1,86312E-04	2,14640E+00	9,99724E-01	9,99701E-01	-0,15
4	1,86260E-04	2,14704E+00	1,00434E-01	9,96300E+00	-0,09
5	1,87068E-05	2,15501E-01			
6	1,86256E-04	2,15561E-01	9,99540E-01	9,99471E-01	-0,16
7	1,86170E-04	2,15675E-01	1,00157E-01	9,99079E+00	-0,06
8	1,86462E-05	2,15874E-02			
9	1,86110E-04	1,85298E-02	9,99540E-01	9,99240E-01	-0,12
10	1,86024E-04	1,85439E-02	**Reference Level**		**0,00**
11	1,86518E-05	1,85819E-03	9,97356E+00	1,00205E-01	-0,06
12	1,86973E-04	1,85708E-03			

	Conversion [dBm] → [mW]		Calculation as given		Calculation as given
n	**Ref / R [mW]**	**DUT / D [mW]**	**Relation1 / A $= R_{n+1}/R_n$**	**Relation2 / B $= D_n/D_{n+1}$**	**Non-Linearity $= A_n*B_n\ (NL_{n\pm1}+1) - 1$ ① [%]**
13	1,86857E-04	1,85810E-03	1,00062E+00	1,00055E+00	0,06
14	1,87068E-05	1,85849E-04	9,98872E+00	1,00021E-01	-0,03
15	1,87245E-04	1,85935E-04			
16	1,87150E-04	1,86050E-04	1,00051E+00	1,00062E+00	0,08
17	1,87206E-05	1,85973E-05	9,99701E+00	9,99586E-02	0,01
18	1,87443E-04	1,86149E-05			
19	1,87335E-04	1,86264E-05	1,00058E+00	1,00062E+00	0,13
20	1,87495E-05	1,86312E-06	9,99148E+00	1,00025E-01	0,07

NOTE ①: The Nonlinearity is calculated recursively using n=11 as reference point. The formula is:

$$NL_n = \begin{cases} A_n/B_n \cdot (NL_{n+1}+1)-1 & for\ n \prec 10 \\ A_n/B_n \cdot (NL_{n-1}+1)-1 & for\ n \succ 10 \end{cases}$$

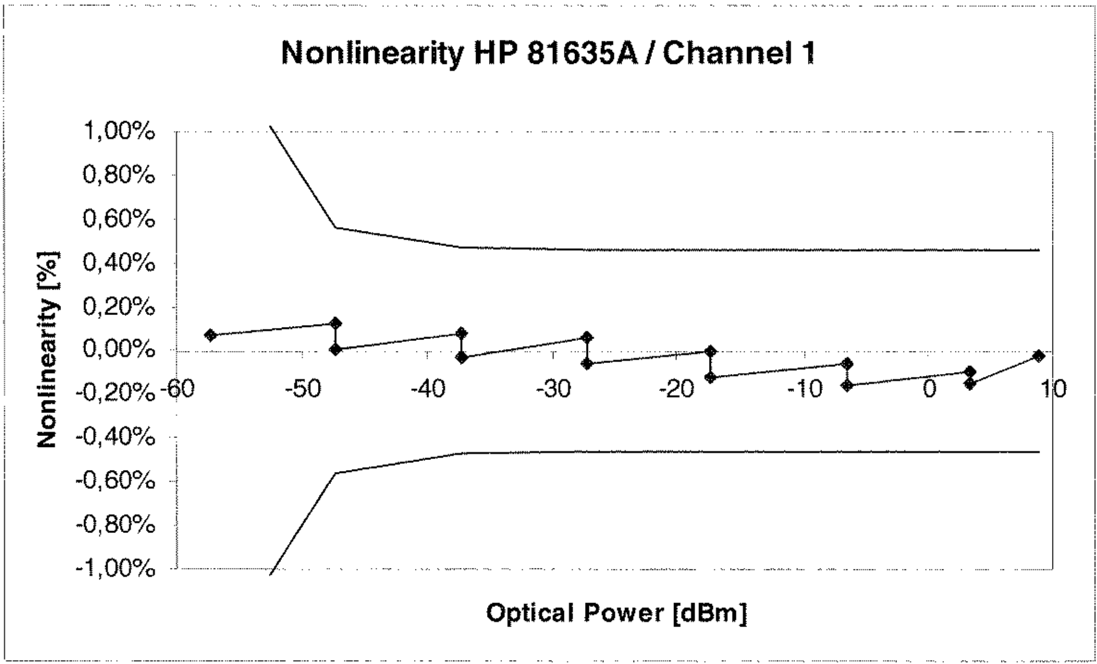

Figure 4 Linearity Test

Noise Test

1 Insert the device under test, a 8163xA Power Sensor, into a slot of the 8163A mainframe. Make sure the optical input of the Device Under Test (DUT), 8163xA, is not receiving any light by placing a plastic cap over the input. Move to the DUT Power Meter channel, press [Menu], move to <*Zero*>, and press *Enter*.

2 Press *Appl*, move to <*Stability*>, and press *Enter*. The Stability Setup Screen appears.

3 Ensure, that the correct channel is selected in the upcoming Module Selection box.

4 Press [Menu] to access the Logging application menu screen.

5 Move to <*Pwr unit*>, press *Enter*, move to <*W*>, and press *Enter*.

6 Move to <*AvgTime*>, press *Enter*, move to <*1 s*>, and press *Enter*.

7 Move to <*Range mode*>, press *Enter*, move to <*Auto*>, and press *Enter*, and press [Close].

8 Press the [Parameter] softkey, move to [*TotalTime*], press *Enter*, set the total time to 00:05:00, which is 5 minutes, and press *Enter*.

9 Press the [Measure] softkey to start the measurement.

10 After the stability application has finished, press the [Analysis] softkey, press the [more] softkey, and note [Δ*P*] as the noise value in the test record.

Return Loss Test

1 Connect the equipment as shown in Figure 5/①. Alternatively, you can use a clean and undamaged straight fiber end as a reference reflector.

2 Move to the fixed wavelength Laser Source channel, select [Menu] and set the <*Modulation src 15xx.xnm*> to <*Coherence Ctrl*>. Ensure, that you set the modulation of the upper wavelength source if you are using a Agilent 81657A Laser Source.

3 Set the attenuation of the Agilent 8156A optical attenuator to 10.0 dB at the wavelength given by the source module and enable the output of the attenuator.

4 Set the averaging time of the Return Loss Module to 1s by pressing *Param* and set the wavelength to the wavelength of the Laser Source.

5 Zero the Return Loss Module.

6 Select the reference parameter, R, by pressing *Param* and set this to 0.18 dB (in case of a straight fiber end as reflector, set the reference to 14.7 dB).

7 Enable the source output and press *Disp→Ref* for the Return Loss Module.

8 Select the termination parameter T by pressing *Param*.

9 Disconnect the Agilent 81102SC and the Agilent 8156A #203 patchcords from each other.

10 Press *Disp→Ref* for the Return Loss Module.

11 Ensure, that the termination parameter T at the Return Loss Module shows a reading of more than 50dB.

12 Connect the DIN-connector of the 81102SC patchcord to the sensor module as shown in Figure 5/②.

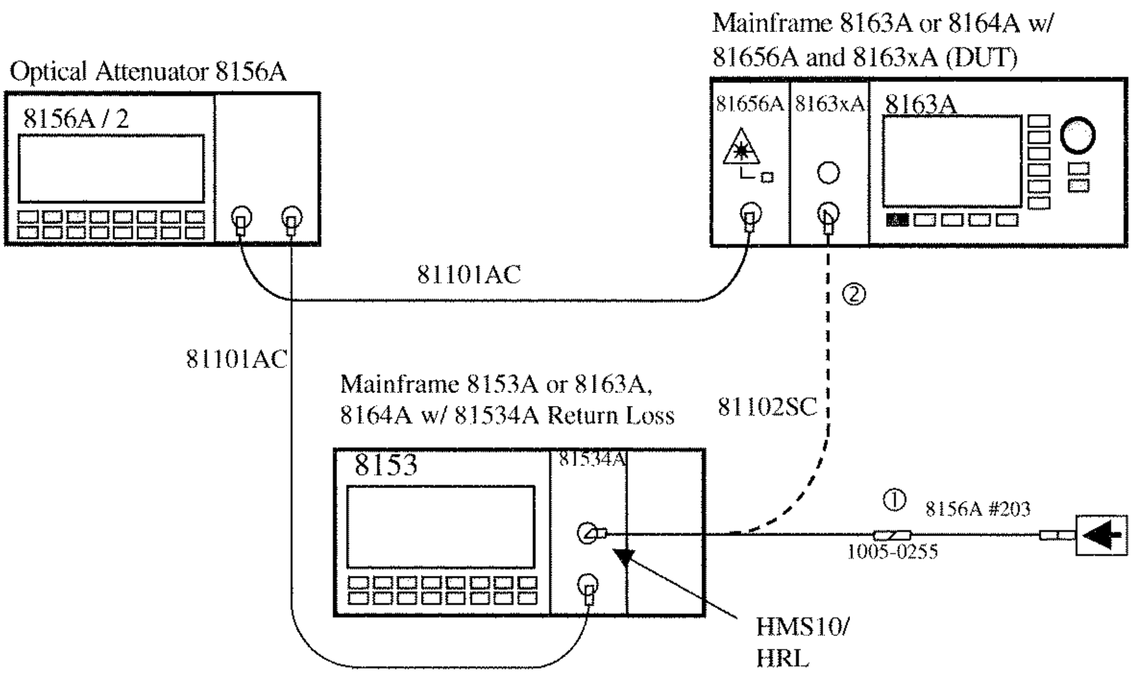

Figure 5 Return Loss Measurement Setup

13 Note the result as the return loss of the sensor module into the test record.

Relative Uncertainty due to Polarization (Optional Test)

NOTE The performance test "Relative Uncertainty due to Polarization" is optional, since the polarization is given with the production of the unit by mechanical and optical cavities and stays unchanged by normal use of the sensor module.

Below, you will find the test setup to verify the relative uncertainty due to polarization of the sensor module. Generally, during this measurement-procedure the tunable laser source is swept through a predefined wavelength range. After every wavelength step, a single PDL-measurement is made, where the polarization controller generates all different polarization states. The highest PDL value is taken as the "relative uncertainty due to polarization". The low output power path of the coupler is used to monitor the power stability of the setup.

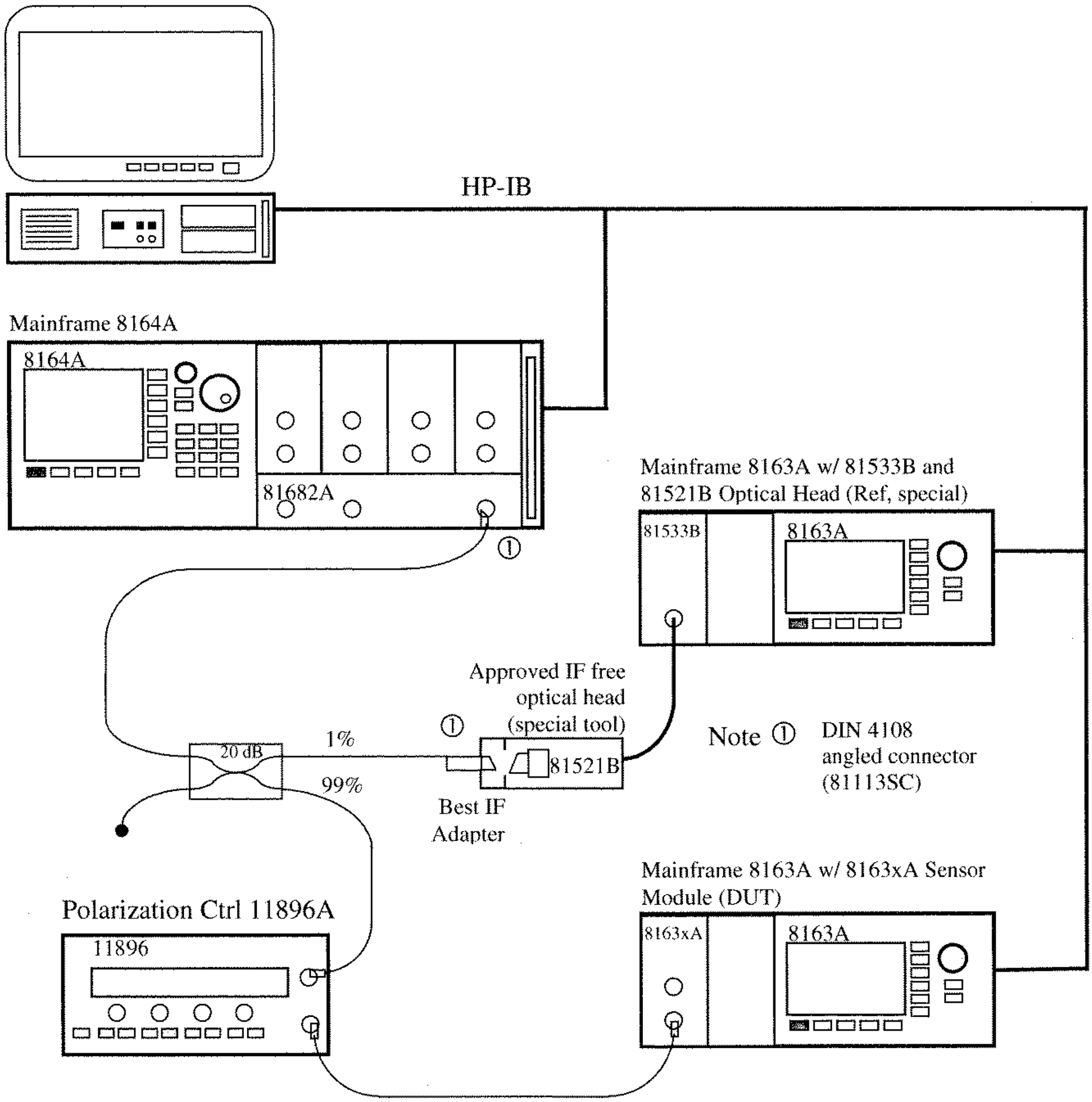

Figure 6 Measurement Setup for PDL Test

Relative Uncertainty due to Interference (Optional Test)

NOTE The performance test "Relative Uncertainty due to Interference" is optional, since the interference is given with the production of the unit by mechanical and optical cavities and stays unchanged by normal use of the sensor module.

Below, you will find the test setup to verify the relative uncertainty due to interference of the sensor module. In order to perform the relative uncertainty due to interference test, it is mandatory to use two mainframes, since the time difference between measurement A und B for a specific wavelength point has to be at most 2 ms. Due to this short measurement interval, the performance test of the relative uncertainty due to interference can only be using computer control.

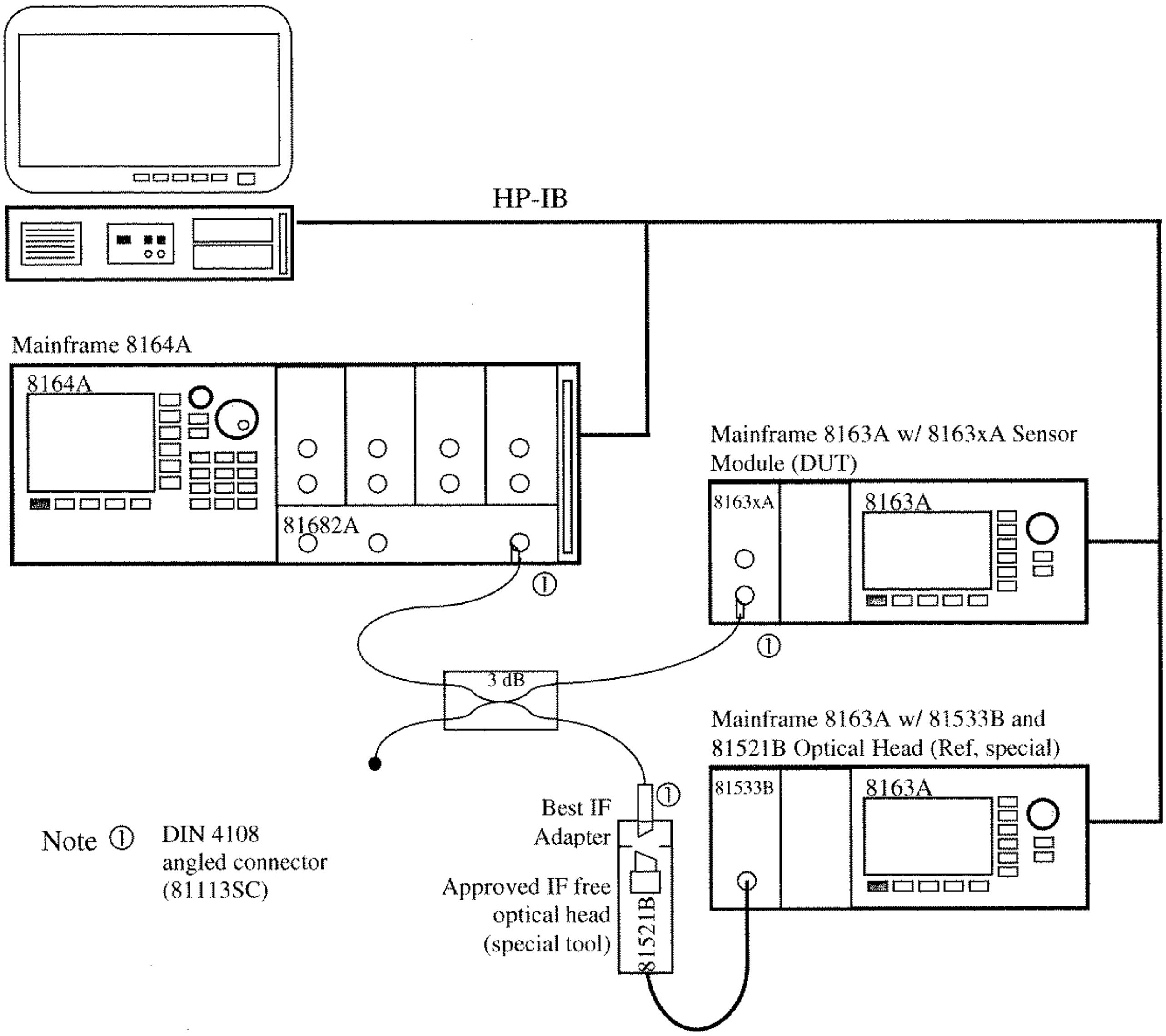

Figure 7 Setup for Relative Uncertainty due to Interference Measurement

Theoretically, both Power Meters are monitoring the power ratio over the variable wavelength in a predefined range as shown in Figure 8. Ensure that the tunable laser source is mode-hop free in the tested wavelength range.

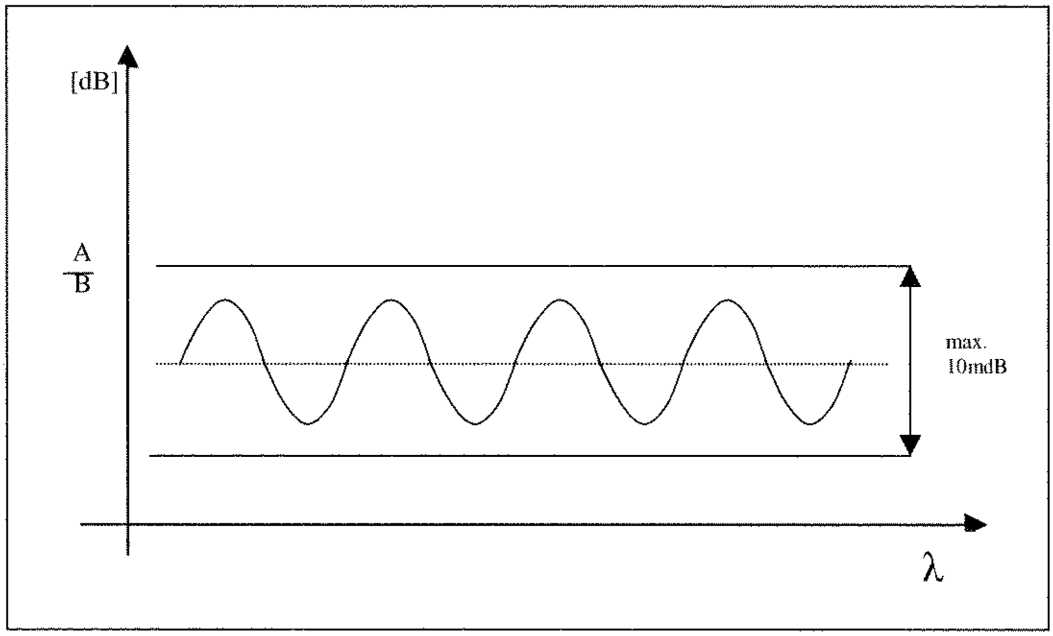

Figure 8 Interference Ripple

Performance Test for the Agilent 81632A

Page 1 of 3

Model	Agilent 81632A Sensor Module____	Date	__________
Serial No.	______________________	Ambient Temperature	__________ °C
Options	______________________	Relative Humidity	__________ %
Firmware Rev.	______________________	Line Frequency	__________ Hz
Test Facility	______________________	Customer	______________________
Performed by	______________________	Report No	______________________

Special Notes ____

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Performance Test for the Agilent 81632A **Test Equipment Used**

Page 2 of 3

	Description	Model No.	Trace No	Cal. Due Date
1a1	Lightwave Multimeter (Std.)	Agilent 8163A	________	________
1a2	Lightwave Multimeter (DUT)	Agilent 8163A	________	________
1b	TLS Mainframe	Agilent 8164A	________	________
2a1	CW High Power Laser Source	Agilent 81655A	________	________
2a2	CW High Power Laser Source	Agilent 81656A	________	________
2b	CW Dual High Power Laser Source	Agilent 81657A	________	________
3	CW Dual Laser Source	HP 81554SM	________	________
4a1	Opt. Head Interface Module	HP 81533B	________	________
4a2	Optical Head, Reference	HP 81521B	________	________
5	Sensor Module	HP 81532A	________	________
6	Optical Attenuator	Agilent 8156A #221	________	________
7a	Optical Attenuator	Agilent 8156A #101	________	________
7b	Optical Attenuator	HP 8157A	________	________
7c	Optical Attenuator	HP 8158B #002	________	________
8	Return Loss Module	HP 81534A	________	________
9	________________	________	________	________
10	________________	________	________	________
11	________________	________	________	________
12	________________	________	________	________

Accessories	#	Product	#	Product	#	Product
Singlemode Fibers	2	81101AC	1	81102SC	1	81109AC
	3	81113PC	1	81113SC		
Connector Interfaces	5	81000AI	3	81000FI	5	81000SI
Connector Adapters	1	81000AA				
Backreflector Kit	1	8156A #203				

Performance Test for the Agilent 81632A

Page 3 of 3

Model Agilent 81632A Sensor Module **Report No.**________ **Date** ________________

Test No.	Test Description		Min. Spec.	Result	Max. Spec.	Measurement Uncertainty
I	**Accuracy Test**			*[μW]*		
	measured at _______ nm (1310nm)	Output Power	9.64 μW	_______	10.36 μW	
	measured at _______ nm (1550nm)	Output Power	9.64 μW	_______	10.36 μW	

II **Linearity Test** For Calculations you may want to use the appropriate sheet

Range	P_{DUT} [dBm]	P_{DUT} [dBm]	Loss [%]	
+10	+9	_______	_______	<± 0.93 %
+10	+3	_______	_______	<± 0.46 %
0	+3	_______	_______	<± 0.46 %
0	-7	_______	_______	<± 0.46 %
-10	-7	_______	_______	<± 0.46 %
-10	-17	_______	_______	<± 0.46 %
-20*	-17*	Reference	**0.0**	<± 0.46 %
-20	-27	_______	_______	<± 0.46 %
-30	-27	_______	_______	<± 0.46 %
-30	-37	_______	_______	<± 0.47 %
-40	-37	_______	_______	<± 0.47 %
-40	-47	_______	_______	<± 0.56 %
-50	-47	_______	_______	<± 0.56 %
-50	-57	_______	_______	<± 1.46 %

III **Noise Test** [pW]

_______ < 20 pW

IV **Return Loss Test** [dB]

40 dB < _______

Performance Test for the Agilent 81633A

Page 1 of 3

Model	Agilent 81633A Sensor Module___	Date	__________
Serial No.	______________________	Ambient Temperature	__________°C
Options	______________________	Relative Humidity	__________ %
Firmware Rev.	______________________	Line Frequency	__________ Hz
Test Facility	______________________	Customer	______________________
Performed by	______________________	Report No	______________________

Special Notes ____

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Performance Test for the Agilent 81633A **Test Equipment Used**

Page 2 of 3

	Description	Model No.	Trace No	Cal. Due Date
1a1	Lightwave Multimeter (Std.)	Agilent 8163A	________	________
1a2	Lightwave Multimeter (DUT)	Agilent 8163A	________	________
1b	TLS Mainframe	Agilent 8164A	________	________
2a1	CW High Power Laser Source	Agilent 81655A	________	________
2a2	CW High Power Laser Source	Agilent 81656A	________	________
2b	CW Dual High Power Laser Source	Agilent 81657A	________	________
3	CW Dual Laser Source	HP 81554SM	________	________
4a1	Opt. Head Interface Module	HP 81533B	________	________
4a2	Optical Head, Reference	HP 81521B	________	________
5	Sensor Module	HP 81532A	________	________
6	Optical Attenuator	Agilent 8156A #221	________	________
7a	Optical Attenuator	Agilent 8156A #101	________	________
7b	Optical Attenuator	HP 8157A	________	________
7c	Optical Attenuator	HP 8158B #002	________	________
8	Return Loss Module	HP 81534A	________	________
9	________________	________	________	________
10	________________	________	________	________
11	________________	________	________	________
12	________________	________	________	________

Accessories	#	**Product**	#	**Product**	#	**Product**
Singlemode Fibers	2	81101AC	1	81102SC	1	81109AC
	3	81113PC	1	81113SC		
Connector Interfaces	5	81000AI	3	81000FI	5	81000SI
Connector Adapters	1	81000AA				
Backreflector Kit	1	8156A #203				

Performance Test for the Agilent 81633A

Page 3 of 3

Model Agilent 81633A Sensor Module **Report No.**________ **Date** ________________

Test No.	Test Description			Min. Spec.	Result	Max. Spec.	Measurement Uncertainty
I	**Accuracy Test**				*[µW]*		
	measured at _______ nm (1310nm) Output Power			9.69 µW	_______	10.31 µW	
	measured at _______ nm (1550nm) Output Power			9.69 µW	_______	10.31 µW	
II	**Linearity Test**	For Calculations you may want to use the appropriate sheet					
	Range	**P_{DUT} [dBm]**	**P_{DUT} [dBm]**		**Loss [%]**		
	+10	+9	_______		_______	<± 0.35 %	
	+10	+3	_______		_______	<± 0.35 %	
	0	+3	_______		_______	<± 0.35 %	
	0	-7	_______		_______	<± 0.35 %	
	-10	-7	_______		_______	<± 0.35 %	
	-10	-17	_______		_______	<± 0.35 %	
	-20*	-17*	Reference		**0.0**	<± 0.35 %	
	-20	-27	_______		_______	<± 0.35 %	
	-30	-27	_______		_______	<± 0.35 %	
	-30	-37	_______		_______	<± 0.35 %	
	-40	-37	_______		_______	<± 0.35 %	
	-40	-47	_______		_______	<± 0.36 %	
	-50	-47	_______		_______	<± 0.36 %	
	-50	-57	_______		_______	<± 0.45 %	
III	**Noise Test**				[pW]		
					_______	< 2 pW	
IV	**Return Loss Test**				[dB]		
				55 dB <	_______		
(V)	**Relative Uncertainty due to Polarization**				[dB]		
	Maximum difference in interval 1550 nm - 1560 nm / 0.1 nm step; ΔP				_______	< 0.01 dB	
(VI)	**Relative Uncertainty due to Interference**				[dB]		
	Maximum difference in interval 1500 nm - 1560 nm / 2 pm step; ΔP				_______	< 0.01 dB	

Performance Test for the Agilent 81634A

Page 1 of 3

Model	Agilent 81634A Sensor Module___	Date	____________
Serial No.	____________________________	Ambient Temperature	____________°C
Options	____________________________	Relative Humidity	____________ %
Firmware Rev.	____________________________	Line Frequency	____________ Hz
Test Facility	____________________________	Customer	____________________________
Performed by	____________________________	Report No	____________________________

Special Notes ____

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Performance Test for the Agilent 81634A **Test Equipment Used**

Page 2 of 3

	Description	Model No.	Trace No	Cal. Due Date
1a1	Lightwave Multimeter (Std.)	Agilent 8163A	________	________
1a2	Lightwave Multimeter (DUT)	Agilent 8163A	________	________
1b	TLS Mainframe	Agilent 8164A	________	________
2a1	CW High Power Laser Source	Agilent 81655A	________	________
2a2	CW High Power Laser Source	Agilent 81656A	________	________
2b	CW Dual High Power Laser Source	Agilent 81657A	________	________
3	CW Dual Laser Source	HP 81554SM	________	________
4a1	Opt. Head Interface Module	HP 81533B	________	________
4a2	Optical Head, Reference	HP 81521B	________	________
5	Sensor Module	HP 81532A	________	________
6	Optical Attenuator	Agilent 8156A #221	________	________
7a	Optical Attenuator	Agilent 8156A #101	________	________
7b	Optical Attenuator	HP 8157A	________	________
7c	Optical Attenuator	HP 8158B #002	________	________
8	Return Loss Module	HP 81534A	________	________
9	________	________	________	________
10	________	________	________	________
11	________	________	________	________
12	________	________	________	________

Accessories	#	Product	#	Product	#	Product
Singlemode Fibers	2	81101AC	1	81102SC	1	81109AC
	3	81113PC	1	81113SC		
Connector Interfaces	5	81000AI	3	81000FI	5	81000SI
Connector Adapters	1	81000AA				
Backreflector Kit	1	8156A #203				

Performance Test for the Agilent 81634A

Page 3 of 3

Model Agilent 81634A Sensor Module **Report No.________** **Date ________________**

Test No.	Test Description			Min. Spec.	Result	Max. Spec.	Measurement Uncertainty
I	**Accuracy Test**				*[μW]*		
	measured at _______ nm (1310nm)		Output Power	9.69 μW	______	10.31 μW	
	measured at _______ nm (1550nm)		Output Power	9.69 μW	______	10.31 μW	
II	**Linearity Test**		For Calculations you may want to use the appropriate sheet				
	Range	**P_{DUT} [dBm]**	**P_{DUT} [dBm]**		**Loss [%]**		
	+10	+9	_______		______	<± 0.35 %	
	+10	+3	_______		______	<± 0.35 %	
	0	+3	_______		______	<± 0.35 %	
	0	-7	_______		______	<± 0.35 %	
	-10	-7	_______		______	<± 0.35 %	
	-10	-17	_______		______	<± 0.35 %	
	-20*	-17*	Reference		**0.0**	<± 0.35 %	
	-20	-27	_______		______	<± 0.35 %	
	-30	-27	_______		______	<± 0.35 %	
	-30	-37	_______		______	<± 0.35 %	
	-40	-37	_______		______	<± 0.35 %	
	-40	-47	_______		______	<± 0.35 %	
	-50	-47	_______		______	<± 0.35 %	
	-50	-57	_______		______	<± 0.36 %	
III	**Noise Test**				[pW]		
					______	< 2 pW	
IV	**Return Loss Test**				[dB]		
				55 dB <	______		
(V)	**Relative Uncertainty due to Polarization**				[dB]		
	Maximum difference in interval 1550 nm - 1560 nm / 0.1 nm step; ΔP				______	< 0.01 dB	
(VI)	**Relative Uncertainty due to Interference**				[dB]		
	Maximum difference in interval 1500 nm - 1560 nm / 2 pm step; ΔP				______	< 0.01 dB	

Performance Test for the Agilent 81635A

Page 1 of 3

Model	Agilent 81635A Sensor Module___	Date	___________
Serial No.	____________________	Ambient Temperature	___________°C
Options	____________________	Relative Humidity	___________ %
Firmware Rev.	____________________	Line Frequency	___________ Hz
Test Facility	____________________	Customer	____________________
Performed by	____________________	Report No	____________________

Special Notes ____

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Performance Test for the Agilent 81635A **Test Equipment Used**

Page 2 of 3

	Description	Model No.	Trace No	Cal. Due Date
1a1	Lightwave Multimeter (Std.)	Agilent 8163A	________	________
1a2	Lightwave Multimeter (DUT)	Agilent 8163A	________	________
1b	TLS Mainframe	Agilent 8164A	________	________
2a1	CW High Power Laser Source	Agilent 81655A	________	________
2a2	CW High Power Laser Source	Agilent 81656A	________	________
2b	CW Dual High Power Laser Source	Agilent 81657A	________	________
3	CW Dual Laser Source	HP 81554SM	________	________
4a1	Opt. Head Interface Module	HP 81533B	________	________
4a2	Optical Head, Reference	HP 81521B	________	________
5	Sensor Module	HP 81532A	________	________
6	Optical Attenuator	Agilent 8156A #221	________	________
7a	Optical Attenuator	Agilent 8156A #101	________	________
7b	Optical Attenuator	HP 8157A	________	________
7c	Optical Attenuator	HP 8158B #002	________	________
8	Return Loss Module	HP 81534A	________	________
9	________	________	________	________
10	________	________	________	________
11	________	________	________	________
12	________	________	________	________

Accessories	#	Product	#	Product	#	Product
Singlemode Fibers	2	81101AC	1	81102SC	1	81109AC
	3	81113PC	1	81113SC		
Connector Interfaces	5	81000AI	3	81000FI	5	81000SI
Connector Adapters	1	81000AA				
Backreflector Kit	1	8156A #203				

Performance Test for the Agilent 81635A

Page 3 of 3

Model Agilent 81632A Sensor Module **Report No.**_______ **Date** _______________

Test No.	**Test Description**		**Min. Spec.**	**Result**	**Max. Spec.**	**Measurement Uncertainty**
I	**Accuracy Test**			*[μW]*		
	measured at _______ nm (1310nm)	Output Power	9.64 μW	______	10.36 μW	
	measured at _______ nm (1550nm)	Output Power	9.64 μW	______	10.36 μW	

II **Linearity Test** For Calculations you may want to use the appropriate sheet

Range	**P_{DUT} [dBm]**	**P_{DUT} [dBm]**	**Loss [%]**	
+10	+9	_______	______	<± 0.93 %
+10	+3	_______	______	<± 0.46 %
0	+3	_______	______	<± 0.46 %
0	-7	_______	______	<± 0.46 %
-10	-7	_______	______	<± 0.46 %
-10	-17	_______	______	<± 0.46 %
-20*	-17*	Reference	**0.0**	<± 0.46 %
-20	-27	_______	______	<± 0.46 %
-30	-27	_______	______	<± 0.46 %
-30	-37	_______	______	<± 0.47 %
-40	-37	_______	______	<± 0.47 %
-40	-47	_______	______	<± 0.56 %
-50	-47	_______	______	<± 0.56 %
-50	-57	_______	______	<± 1.46 %

III **Noise Test** [pW]

______ < 20 pW

IV **Return Loss Test** [dB]

40 dB < ______

Calculation Sheet for Linearity Measurement

	Conversion [dBm] → [mW]		Calculation as given		Calculation as given
n	Ref / R [mW]	DUT / D [mW]	Relation1 / A $= R_{n+1}/R_n$	Relation2 / B $= D_n/D_{n+1}$	Non-Linearity $= A_n*B_n\ (NL_{n\pm1}+1) - 1$ ① [%]
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Cleaning Procedure

In general, *whenever possible use physically contacting connectors, and dry connections*. Clean the connectors, interfaces and bushings carefully each time after use.

WARNING

Make sure to disable all sources when you are cleaning any optical interfaces. Under no circumstances look into the end of an optical cable attached to the optical output when the device is operational.
The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.

WARNING

To prevent electrical shock, disconnect the instrument from the mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

The Cleaning Kit

A full cleaning kit contains the following items:

Isopropyl alcohol

This is usually available from pharmaceutical suppliers or chemists.

If possible, use alcohol supplied for medical purposes, rather than impure alcohol or alcohol with additives.

CAUTION Do not use other solvents as some can damage plastic materials and claddings. For example, Acetone dissolves the adhesives used in fiber optic devices.

WARNING Never drink this alcohol as this can lead to blindness or other serious damage to your health.

Cotton-swabs

Use swabs such as Q-tips or other cotton-swabs. These are typically available from local distributors of medical or hygiene products (such as supermarkets or pharmacies).

NOTE If you are cleaning connector interfaces or adapters, the diameter of the cotton swab is important. Cotton swabs for babies normally have a smaller diameter.

CAUTION Do not use foam swabs, as these can leave filmy deposits on the surface you are cleaning.
Store your cotton-swabs carefully and never reuse them. Dust and dirt from the air or from previous cleaning, can scratch or dirty your optical device.

Soft-tissues

These are available from most stores and distributors of medical and hygiene products (such as supermarkets or pharmacies).

Use multi-layer tissues made from non-recycled cellulose. These are more absorbent and softer than other types and they do not scratch the surface of your device.

CAUTION Store your soft-tissues carefully and never reuse them, as dust and dirt from the air or from previous cleaning can scratch and dirty your optical device.

Pipe-cleaner

These are available from tobacco shops.

Ensure that the bristles of the pipe-cleaner are soft, so that they do not scratch your device during cleaning.

CAUTION Store your pipe-cleaner carefully and never reuse them as dust and dirt from the air or from previous cleaning can scratch and dirty your optical device.

Compressed Air

This is available from laboratory suppliers.

It is essential that your compressed air is free of dust, water and oil. Only use clean, dry air. If you do not, it can lead to filmy deposits or scratches.

When using compressed air from a can,

- Hold the can upright. A slant can cause propellant to escape with the compressed air and dirty your optical device.
- Spray the first couple of seconds into the air, as the first stream of compressed air can contain condensation or propellant. Any condensation produces a filmy deposit.

If you are using compressed air from a can, you should select one with a CFC-free propellant, for the sake of the environment.

Other Cleaning Tools

To examine devices you also require:

Microscope

Select a microscope with a magnification range of between 50X and 300X. These should be available from photographic stores or laboratory suppliers.

Ensure that the light source of the microscope is flexible. This helps you to examine your device closely and from different angles.

A microscope allows you to determine the type of dirt on your device and its extent. Then you can choose the correct cleaning procedure and later to examine the results of cleaning. With a microscope you can also determine if your optical device is scratched.

Ultrasonic bath

These are typically available from photographic stores or laboratory suppliers.

An ultrasonic bath very gently removes greasy and other stubborn dirt from optical devices.

Only use an ultrasonic bath with isopropyl alcohol, as other solvents can damage or dirty your optical device.

Warm water and liquid soap

Use water only if you are sure that your optical device will not corrode or be damaged. Do not use hot water, as this can lead to mechanical stress that can damage your optical device. Ensure that your liquid soap has no abrasive properties or perfume in it, as these can scratch or damage your optical device. Do not use normal washing-up liquid, as it can leave behind an iridescent film.

Premoistened cleaning wipes

These are tissues that are moistened with isopropyl alcohol.

Polymer film

This is typically available from professional photographic stores or laboratory suppliers.

Polymer film is very gentle on optical surfaces and is particularly good for cleaning extremely sensitive devices such as mirrors.

Infrared sensor card

This is typically available from laboratory suppliers.

With this card you can qualitatively check the uniformity of your emitted laser light, because when the laser light is projected onto the sensor card it becomes visible.

Lens Cleaning Paper

Some lens cleaning papers and cleaning kits available, for example, in photographic stores are not suitable for cleaning fiber optic devices. To be sure, please ask the salesperson or the manufacturer.

Preserving Connectors

Listed below are some hints on how best to keep your connectors in the best possible condition.

Making Connections

Before you make any connection you must ensure that all cables and connectors are clean. If they are dirty, use the appropriate cleaning procedure.

When inserting the ferrule of a patchcord into a connector or an adapter, make sure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise you will rub the fiber end against an unsuitable surface, producing scratches and dirt deposits on the surface of your fiber.

Dust Caps and Shutter Caps

Be careful when replacing dust caps after use. Do not press the bottom of the cap onto the fiber as any dust in the cap can scratch or dirty your fiber surface.

When you have finished cleaning, put the dust cap back on, or close the shutter cap if the equipment is not going to be used immediately.

Keep the caps on the equipment always when it is not in use.

All of Agilent Technologies's lightwave instruments and accessories are shipped with either laser shutter caps or dust caps. If you need additional or replacement dust caps, contact your nearest Agilent Technologies Sales/Service Office.

Immersion Oil and Other Index Matching Compounds

Where it is possible, do not use immersion oil or other index matching compounds with your device. They are liable to impair and dirty the surface of the device. In addition, the characteristics of your device can be changed and your measurement results affected.

Cleaning Instrument Housings

Use a dry and very soft cotton tissue to clean the instrument housing and the keypad. Do not open the instruments as there is a danger of electric shock, or electrostatic discharge. Opening the instrument can cause damage to sensitive components, and in addition your warranty will be voided.

Cleaning Procedures

If you are unsure about the correct cleaning procedure for your device or if you are unsure whether the procedure given here is suitable for your device, check with the manufacturer or sales distributor, or try the procedure on a dummy or test device first.

Cleaning Cable Connectors

Cleaning connectors is difficult as the core diameter of a singlemode fiber is only about 9 μm. This generally means you cannot see streaks or scratches on the surface. To be certain of the condition of the surface of your connector and to check it after cleaning, you need a microscope.

In the case of scratches, or of dust that has been burnt onto the surface of the connector, you may have no option but to polish the connector. This depends on the degree of dirtiness, or the depth of the scratches. This is a difficult procedure and should only be performed by skilled personal, and as a last resort as it wears out your connector.

WARNING Never look into the end of an optical cable that is connected to an active source.

To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the output of the connector. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

Preferred Procedure

1 Clean the connector by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the connector:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the connector by rubbing the cotton-swab over the surface using a small circular movement.

3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

4 Blow away any remaining lint with compressed air.

An Alternative Procedure

The better, more gentle, but more expensive cleaning procedure is to use an ultrasonic bath with isopropyl alcohol.

1 Hold the tip of the connector in the bath for at least three minutes.

2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

Cleaning Connector Adapters

CAUTION

Some adapters have an anti-reflection coating on the back to reduce back reflection. This coating is extremely sensitive to solvents and mechanical abrasion. Extra care is needed when cleaning these adapters.

Preferred Procedure

1 Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the adapter:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the adapter by rubbing the cotton-swab over the surface using a small circular movement.

3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

4 Blow away any remaining lint with compressed air.

Cleaning Connector Interfaces

CAUTION

Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the interface.
Do not use pipe-cleaners on optical head adapters, as the hard core of normal pipe cleaners can damage the bottom of an adapter.

Preferred Procedure

1. Clean the interface by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.
2. Then clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
3. Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface:

1. Moisten a new pipe-cleaner with isopropyl alcohol.
2. Clean the interface by pushing and pulling the pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.
3. Moisten a new cotton-swab with isopropyl alcohol.
4. Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
5. Using a new, dry pipe-cleaner, and a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.
6. Blow away any remaining lint with compressed air.

Cleaning Bare Fiber Adapters

Bare fiber adapters are difficult to clean. Protect from dust unless they are in use.

CAUTION

Never use any kind of solvent when cleaning a bare fiber adapter as solvents can damage the foam inside some adapters.
They can deposit dissolved dirt in the groove, which can then dirty the surface of an inserted fiber.

Preferred Procedure

1. Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the adapter:

CAUTION

Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the adapter.

1. Clean the adapter by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.

2 Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

Cleaning Bare Fiber Ends

Bare fiber ends are often used for splices or, together with other optical components, to create a parallel beam. The end of a fiber can often be scratched. You make a new cleave. To do this:

1 Strip off the cladding.

2 Take a new soft-tissue and moisten it with isopropyl alcohol.

3 Carefully clean the bare fiber with this tissue.

4 Make your cleave and immediately insert the fiber into your bare fiber adapter in order to protect the surface from dirt.

Cleaning Lenses

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings.

Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little alcohol as possible, as it can get between the lenses and in doing so can change the properties of projection.

Preferred Procedure

1 Clean the lens by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the lens:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the lens by rubbing the cotton-swab over the surface using a small circular movement.

3 Using a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.

4 Blow away any remaining lint with compressed air.

Cleaning Large Area Lenses and Mirrors

CAUTION

Some mirrors, as those from a monochromator, are very soft and sensitive. Therefore, never touch them and do not use cleaning tools such as compressed air or polymer film.
Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings.
Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little liquid as possible, as it can get between the lenses and in doing so can change the properties of projection.

Preferred Procedure

1 Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the lens:

CAUTION

Only use water if you are sure that your device does not corrode.
Do not use hot water as this can lead to mechanical stress, which can damage your device.
Make sure that your liquid soap has no abrasive properties or perfume in it, because they can scratch and damage your device.
Do not use normal washing-up liquid as sometimes an iridescent film remains.

1 Moisten the lens or the mirror with water.

2 Put a little liquid soap on the surface and gently spread the liquid over the whole area.

3 Wash off the emulsion with water, being careful to remove it all, as any remaining streaks can impair measurement accuracy.

4 Take a new, dry soft-tissue and remove the water, by rubbing gently over the surface using a small circular movement.

5 Blow away remaining lint with compressed air.

Alternative Procedure A

To clean lenses that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.

2 Remove the film and any dirt with special adhesive tapes.

Alternative Procedure B

If your lens is sensitive to water then:

1 Moisten the lens or the mirror with isopropyl alcohol.

2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

3 Blow away remaining lint with compressed air.

Cleaning Fixed Connector Interfaces

Generally, avoid cleaning this kind of interface, because it is difficult to remove any used alcohol or lint from the input of the optical block. Keep the dust caps on the interfaces unless it is in use.

If there is dust on the interface, try cleaning it using compressed air.

If there is fluid or greasy dirt on the interface then contact Agilent Technologies, so that trained personnel can open the instrument and do the cleaning. Never open the instrument to clean the optical block yourself, because the optical components can be easily scratched or misaligned.

Cleaning Optical Glass Plates

Some instruments, for example, the optical heads from Agilent Technologies have an optical glass plate to protect the sensor. Clean this glass plate in the same way as optical lenses (see *"Cleaning Lenses" on page 64*).

Cleaning Physical Contact Interfaces

Remove any connector interfaces from the optical output of the instrument before you start the cleaning procedure.

Cleaning interfaces is difficult as the core diameter of a singlemode fiber is only about 9 µm. This generally means you cannot see streaks or scratches on the surface. To be certain of the degree of pollution on the surface of your interface and to check whether it has been removed after cleaning, you need a microscope.

WARNING Never look into an optical output, because this can seriously damage your eye sight.

To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the interface. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

Preferred Procedure

1. Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
2. Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface:

1. Moisten a new cotton-swab with isopropyl alcohol.
2. Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
3. Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
4. Blow away any remaining lint with compressed air.

Cleaning Recessed Lens Interfaces

Preferred Procedure

1. Blow away any dust or dirt with compressed air. If this is not sufficient, then
2. Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
3. Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface, and using the procedure for light dirt is not sufficient. Using isopropyl alcohol should be your last choice for recessed lens interfaces because of the difficulty of cleaning out any dirt that is washed to the edge of the interface:

1. Moisten a new cotton-swab with isopropyl alcohol.
2. Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
3. Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
4. Blow away any remaining lint with compressed air.

Cleaning Fragile Optical Devices

Some optical devices, such as the Agilent 81000BR Reference Reflector, which has a gold plated surface, are very sensitive to mechanical stress or pressure. Do not use cotton-swabs, soft-tissues or other mechanical cleaning tools, as these can scratch or destroy the surface.

Preferred Procedure

1 Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

To clean devices that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.

2 Remove the film and any dirt with special adhesive tapes.

Alternative Procedure

For these types of optical devices you can often use an ultrasonic bath with isopropyl alcohol. Only use the ultrasonic bath if you are sure that it won't cause any damage anything to the device.

1 Put the device into the bath for at least three minutes.

2 Blow away any remaining liquid with compressed air.

If there are any streaks or drying stains on the surface, repeat the cleaning procedure.

Cleaning Metal Filters or Attenuator Gratings

This kind of device is extremely fragile. A misalignment of the grating leads to inaccurate measurements. Never touch the surface of the metal filter or attenuator grating. Be very careful when using or cleaning these devices. Do not use cotton-swabs or soft-tissues, as there is the danger that you cannot remove the lint and that the device will be destroyed by becoming mechanically distorted.

Preferred Procedure

1 Use compressed air at a distance and with low pressure to remove any dust or lint.

Procedure for Stubborn Dirt

Do not use an ultrasonic bath as this can damage your device.

Use this procedure particularly when there is greasy dirt on the device:

1. Put the optical device into a bath of isopropyl alcohol, and wait at least 10 minutes.
2. Remove the fluid using compressed air at some distance and with low pressure. If there are any streaks or drying stains on the surface, repeat the whole cleaning procedure.

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